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REPORT

ON

EXPERIMENTS IN TRAP SIPHONAGE

IN THE

MUSEUM OF HYGIENE,

U. S. NAVY DEPARTMENT,

WASHINGTON, D. C.

By GLENN BROWN, Architect.

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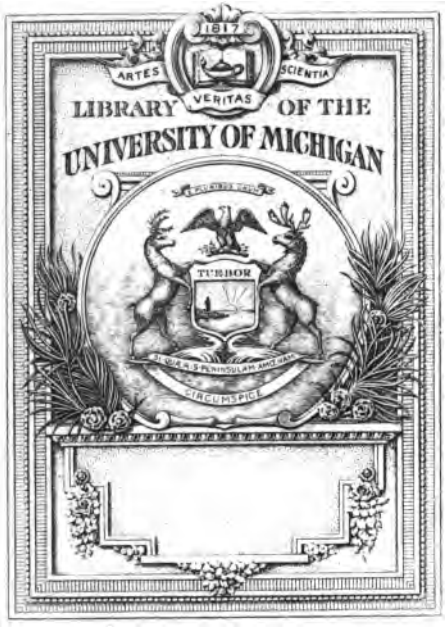
JUDD & DETWEILER, PRINTERS.
1886.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TRAP SIPHONAGE.

The experiments on trap siphonage made by S. S. Hellyer, of London, and similar experiments conducted by Philbrick and Bowditch, of Boston, clearly proved the utility of trap ventilation. The experiments of George E. Waring, of Newport, and J. Pickering Putnam, of Boston, as clearly (apparently) proved the uselessness of such ventilation. In the preparation of a work on plumbing I found this conflict of authorities very perplexing. In fact, it was impossible for any one to form a definite conclusion on the efficiency or inefficiency of trap ventilation without actual experiment. The difficulty and the object to be attained were laid before Dr. J. Mills Browne, medical director United States Navy, in charge of the Museum of Hygiene at that time. Upon consulting with the surgeon general of the Navy the subject was thought of sufficient importance to have a system of iron and lead pipes with fixtures erected outside of the museum building. With these pipes I have been conducting experiments from the fall of 1885 to the present time, as opportunity would permit. The waste and vent pipes are of the sizes used and arranged as in common practice. The traps on which the tests were made were selected so as to cover the different kinds in the market, both mechanical and non-mechanical. The apparatus is so arranged that the fixtures can be subjected to a strain equal to what they would receive in actual use, as well as strains more severe than they would have to withstand, except in unusual contingencies.

The points or places of inspection, and for the attachment of traps, are platforms located on the first, second, third, and fourth stories, as shown in the drawings attached hereto. By this arrangement the effect of water discharged from varying heights can be thoroughly tested in their relations to the different stories of a building. There is a marked change in the effect produced in different stories of a building by a discharge of water from the same point.

The main stack of pipe is of 4-inch extra heavy cast-iron, starting at a connection with the sewer (branches, valves, and connections being inserted at the proper points) and running thence a distance of 32 feet horizontally, and 42 feet vertically, to a point above the roof of the building. In the second story there is an auxiliary stack of 4-inch lead pipe connected with the iron pipe and

running to a point above the roof. Both the iron and lead pipes have running-traps and fresh-air inlets near their point of commencement, with valves and screw-plugs, by which they can be partially or completely closed as desired. By means of a Y-branch the system can be made to empty into the sewer without passing through the running-trap. Either outlet can be used at pleasure, both being governed by gate-valves. Two stacks of 3-inch vent pipe (one lead, the other iron) run vertically from the second story to the roof, thence horizontally along the roof. By means of plugs and valves the lengths of the vents may be varied from a few feet to 42 feet and the openings from 0 to 3 inches. The outlets in both the soil and vent pipes are so arranged that traps from 1¼ to 4 in. can be attached at pleasure, all outlets not in use being cut off by gate-valves or screw-plugs.

Siphonage, caused by the discharge of water through the trap itself from a fixture above, has been found of very little consequence. Siphonage rarely takes place, the water passing over the long arm of the siphon rarely fills the pipe so as to cause the necessary vacuum. When it does take place, the trap fills by the drainage from the fixtures above, such as the wash-basin or sink. The back pressure which comes from sewers would never force the seal of a trap in a house plumbed according to modern practice, the fresh-air inlet and the top of the soil-pipe being always left open. The greatest danger arises from the discharge of large bodies of water down the long vertical four-inch pipes. This column acts to a certain extent like a piston, compressing the air in front of it and creating a vacuum behind it. The air rushing in to fill the vacuum forces or draws the water from the traps into the soil-pipe, while the compressed air finds its easiest mode of escape through the traps below the point of discharge, even when there is a fresh-air opening between the running-trap and the house. Although the water, in case of back pressure, is driven up into the pipe or fixture above the trap and then returns to the trap, *the sewer air passes into the house.* The majority of the experiments have been made to test the power of traps to resist the siphonage and back pressure produced by the column of water passing down the vertical pipes. The question of first importance is: *Does ventilation protect the seal of traps in ordinary use?* This question is answered by the following experiments, in all of which the vent-pipes were open, and a positive effort was made to break the seal of the trap. In the first experiment the fresh-air inlet at the foot of the soil-pipe and the opening at the roof were closed, in this way subjecting the traps to the greatest strain which they

could possibly have to resist for either siphonage or back pressure:

EXPERIMENTS.

No. 1. A 3-inch lead trap was attached to the outlet in the second story and the water discharged from the tank in the fourth story through a 4-inch opening; the column of water passing down the vertical pipe a distance of 30 feet before it reaches the branch to which the trap is attached; the air confined in the 4-inch pipe between the running-trap and the water column was forced out with considerable violence through the vent-pipe; the outlet of vent in trap was 2 inches in diameter and ran into a 3-inch vent-pipe, which extended up above the fourth story; a discharge of 15.5 gallons created a slight commotion in the trap, from a sixteenth to an eight of an inch, splashing out when the trap was full.

No. 2. The same discharge, same condition (except the small amount of water shaken out of the trap), no effect.

No. 3. Same as No. 2.

No. 4. A 1½-inch trap was connected at the same point, the 3-inch lead pipe being removed, inch vent-pipe open, 15.5 gallons discharged from the tank; water only shaken a little; none thrown out.

No. 5. Same conditions; 7.75 gallons discharged through 4-inch opening in tank; no effect on the seal of trap.

No. 6. A discharge of 15.5 gallons through 2-inch opening in tank; no effect on the seal of trap.

No. 7. Same as No. 6.

No. 8. Same as Nos. 6 and 7.

The fresh-air inlet was now opened and the following experiments tried:

No. 9. Sanitas trap attached; 7.75 gallons discharged through 4-inch opening; no effect on seal.

No. 10. Same as No. 9.

No. 11. Same as Nos. 9 and 10.

An opening was now left near the top of the soil-pipe, a practical illustration of an open fresh-air inlet and top of soil-pipe, and the following experiments tried:

No. 12. A 1½-inch lead trap was attached at the same point; 15.5 gallons discharged through the 2-inch opening of the tank; no effect on the seal of trap.

No. 13. Same as No. 12.

No. 15. Fred. Adee's 1¼-inch trap was connected at the same branch of the soil-pipe. 1-inch discharge of 15.5 gallons through the 2-inch opening of the tank. No effect on the water-seal of the trap.

No. 16. Same condition; same effect.

The point of experiment was now transferred to the third story and the traps attached at that point, the discharges being made from the same tank on the fourth story.

No. 17. A 1¼-inch Bennor's trap was connected with the branch from the main soil-pipe; discharge of 15.5 gallons through the 4-inch opening in the tank. No effect on the seal of the trap.

No. 18. A small 1¼-inch S-trap was inserted; the same discharge and the same effect.

No. 19. A 4-inch S-trap was connected. Same discharge; same effect.

The following experiments were made with vents more or less closed:

No. 20. A 4-inch S-trap. The outlet to vent was half closed. There was considerable commotion in the trap, but the seal was not in any way affected by 7.75 gallons discharged from the tank through the 4-inch opening.

No. 21. Same experiment; same effect.

No. 22. The outlet of vent was three-quarter closed, and a discharge of 15.5 gallons was let out of the tank. There was a great commotion in the trap, the water being lowered until only a quarter of an inch seal remained.

No. 23. The 4-inch lead S-trap in position; the top of vent-pipe half closed; no effect from 7.75 gallons discharged through the 4-inch outlet in the tank.

No. 24. The same trap; outlet of vent quarter closed; one discharge from tank through the 4-inch opening in the tank; water lowered five-eighths of an inch in trap.

No. 25. Same as No. 24.

No. 26. The same trap; the top of vent half closed; one discharge of 15.5 gallons through the 2-inch outlet of the tank. The water was lowered five-eighths of an inch.

No. 27. Same as No. 26.

No. 28. Same as Nos. 26 and 27.

No. 29. Same trap; same vent half closed; 15.5 gallons discharged through the 4-inch outlet of the trap. The air was drawn through the trap and 2 inches of water taken out. The seal was not broken. The trap was refilled.

No. 30. Same as No. 29.

No. 31. Same as No. 29.

No. 32. One discharge of 7.75 gallons, the top of vent being seven-eighths closed and the trap was siphoned.

No. 33. Same as 32.

No. 34. Same as Nos. 32 and 33.

A question of equal importance is, *are unventilated traps siphonable or are some varieties siphonable and others not so?* If some are unsiphonable and at the same time not affected by back pressure it

is important to know which they are. The following array of facts will answer the question:

In the following experiments the vent-pipe was closed, unless otherwise noted. The first tried were with the top of soil-pipe open and the fresh-air inlet closed.

No. 35. A 3-inch lead **S**-trap was connected to one of the branches on the second story, and 15.5 gallons was discharged from the tank in the fourth story through the 4-inch opening. The confined air in the pipe between the running-trap and the descending column of water was forced through the trap, carrying the water with it. This passage of air continued as long as the water was flowing through the pipe from the tank.

No. 36. Same discharge from the tank. A small amount of water was blown out by back pressure; then the trap was siphoned to 1¼ inch below the seal of the trap.

No. 37. Same as No. 36.

No. 38. Same as Nos. 36 and 37.

No. 39. Twenty-three gallons were discharged through the 4-inch opening in the tank. The water was thrown up above the trap by back pressure, playing above the trap like a fountain, a large part of it falling back into the trap, after which siphonage took place, as in experiment No. 36, leaving an eighth of an inch seal in the trap.

No. 40. A 3-inch lead **S** and a 3-inch lead **U** and a 1½ Sanitas trap were all attached to the same branch on the second floor. 15.5 gallons were discharged from the tank on the fourth floor through a 4-inch opening. The two lead traps were siphoned and half the water taken out of the Sanitas trap.

No. 41. Same as No. 40.

No. 42. Same as Nos. 40 and 41.

No. 43. The two lead traps were then cut off and the discharge sent through the pipe, the Sanitas **S**-trap, was two-thirds emptied.

No. 44. Similar discharge without the trap refilling. The Sanitas trap was siphoned, only an eighth of an inch being left in the trap.

No. 45. A small 1¼-inch **S**-trap was inserted at the same place; 15.5 gallons discharged through the 4-inch opening in the tank. The trap was siphoned.

No. 46. The same trap was removed to the second floor and 15.5 gallons discharged through the 2-inch opening in the tank. The water was blown out of the trap.

No. 47. Same as No. 46.

No. 48. Same as Nos. 46 and 47.

The following experiments were made with the top of the soil-pipe and the fresh-air inlet both open, making a system of pipes the same as are now most commonly used in our houses:

No. 49. A large 4-inch **S**-trap and a 1¼-inch Bennor's trap were con-

nected with the soil-pipe branch in the third story; 15.5 gallons discharged through the 2-inch opening in the tank. The Bennor's trap was not affected, while the 4-inch S-trap was completely siphoned. In this case the S-trap formed a vent for the smaller trap.

No. 50. The S-trap was removed and the same discharge made. The water was completely drawn out of the glass cylinder of the Bennor's trap.

No. 51. Another similar discharge without refilling the trap, and the seal was broken. The water would be drawn by siphonage beyond the ball into the cylinder, when the ball would take its seat, and the water would not pass back into the lower part of the trap. This shows the ball to be effective against the back pressure in a new trap of this make.

No. 52. A Sanitas trap was put in at the same place; same discharge as above. Half of the water was taken out of the trap. The air passed through the trap rapidly, creating a continuous commotion in the water. The bulk of the water seemed to be thrown out against the separator in this trap and to fall back without passing out.

No. 53. Same trap; same discharge, one-eighth of an inch being extracted.

No. 54. Same as No. 53.

No. 55. A 1½-inch lead S-trap, Bowers' 1¼-inch trap, and a 4-inch lead S-trap, all connected at the branch in the third story; a discharge of 15.5 gallons through the 2-inch opening in the tank. The Bower's trap was lowered to within a half inch of the seal, the small S-trap to within 1 inch of the seal, and the large S-trap to within two inches of the seal.

No. 56. Same discharge; the S-traps not affected. A small amount of water drawn from the Bowers' trap. The traps were not refilled.

No. 57. Same discharge; same effect on the S-traps. The Bowers' trap was lowered to within an eighth of an inch of the seal. As soon as the air began to pass freely through the Bowers' trap it acted as a vent for the two S-traps, the air finding its way into the soil-pipe.

No. 58. The small S-trap was removed and 15.5 gallons sent through the pipe from the 2-inch opening in the tank. The Bower's trap not having been refilled, was lowered to the seal; the air passing freely through it formed an excellent vent for the large S-trap.

No. 59. Same experiment, the Bowers' trap partly closed; the S-trap was immediately siphoned, the seal being broken.

No. 60. Same as No. 59.

No. 61. The 4-inch S-trap in same position. The vent was connected with the 3-inch vent-pipe, 20 feet long, closed at the top; 7.75 gallons discharged through the 4-inch open-

ing in the tank. The trap was siphoned, seal being broken, the elasticity of the air in the long vent-pipe having no effect in preventing siphonage.

No. 62. Same as No. 61.

No. 63. A 3-inch lead S-trap was attached to a double Y on the second story. 15.5 gallons were discharged through the 4-inch outlet of the tank, the running trap was cut off, and direct outlet to sewer used. Half an inch was blown out of the trap; the trap was not refilled.

No. 64. Same discharge. A quarter of an inch more was blown out by back pressure.

No. 65. Same discharge; one eight-inch more blown out of the trap.

The following experiments were tried with the top of soil-pipe and fresh-air inlet closed:

No. 66. The Sanitas trap was attached to the outlet in the second story. 15.5 gallons were discharged through the 2-inch outlet in the tank; the seal of trap destroyed by the back-pressure.

No. 67. Same as No. 66.

No. 68. Same as Nos. 66 and 67.

No. 69. Same trap; 7.75 gallons discharged through the 4-inch outlet of the tank; water first blown out of trap, then taken out by suction.

No. 70. Same as No. 69.

No. 71. Same as Nos. 69 and 70.

The following experiments were tried with the top of soil-pipe closed and the fresh-air inlet open:

No. 72. A large 4-inch S-trap was inserted in the third story, a Bennor's trap in second story, and 15.5 gallons discharged through the 4-inch opening in the tank. The seal of the 4-inch trap on the second story was broken, while the seal of the Bennor's trap on the first floor was not affected.

No. 73. Same as No. 72.

No. 74. Same arrangement of traps; 31 gallons discharged through the 4-inch opening in the tank. The S-trap siphoned, ¼ inch, drawn out of Bennor's trap, S-trap refilled.

No. 75. Same arrangement of traps; 15.5 gallons discharged through the 4-inch opening in the tank. The S-trap siphoned, ½ inch, drawn out of Bennor's trap, S-trap refilled.

No. 76. Same conditions. The water would rise slowly, the ball moving perceptibly until it passed over the top of the outgo, a small amount at a time. The vacuum in branch on the second story seemed to be caused by the friction of the column of water passing the branches, as it siphoned before the water column passed the branch.

No. 77. A 1½-inch Sanitas trap was attached to the branch in the third story, and a discharge of 15.5 gallons through the 4-inch openings in the tank. Half of the water was taken out of the trap.

No. 78. Same trap; same conditions. Twenty-seven gallons were let out by accident, and the trap was lowered three-eighths of an inch below the seal.
No. 79. Trap was not refilled; 15.5 gallons discharged; one-quarter of an inch drawn out of the trap.
No. 80. Same trap; same discharge; one-quarter of an inch taken out of the trap.
No. 81. Same as No. 80.
No. 82. Same as Nos. 80 and 81.
No. 83. A 1¼-inch Sanitas was put in same place; a similar discharge. The water was drawn completely out of the trap, leaving only a tablespoonful.
No. 84. Same conditions; 7.75 gallons discharged through the 2-inch opening in tank; same effect on the traps.
No. 85. Same trap was attached on the second story and 7.75 gallons discharged through the 4-inch opening in the tank; half the water was blown out.
No. 86. Same discharge; half the remaining water was blown out.
No. 87. Same discharge; only a sixteenth of an inch left in the trap.
No. 88. Same trap; same conditions; 15.5 gallons were discharged; three-quarters of the water was blown out of the trap.
No. 89. Same discharge; the whole amount of water was blown out, leaving only a trace.

Fresh-air inlet closed; top of the soil-pipe open:

No. 90. A five-inch lead **S**-trap was attached on the horizontal pipe on the first or ground floor, and Decco, Boyles, Zane, and Myers closets were discharged simultaneously with no effect on the trap.
No. 91. Six closets were discharged simultaneously with no effect on the trap.
No. 92. Small **S**-trap was inserted; no effect.
No. 93. Same as No. 92.
No. 94. Discharged 15.5 gallons from the tank; a small amount of water was blown out of the trap.
No. 95. Same as No. 94.
No. 96. Small **S**-trap was inserted in the second story and closets on first story discharged; no effects on the traps.
No. 97. Same as No. 96.
No. 98. Small lead **S**-trap inserted in third story and water-closets discharged on first story; no effect on the trap.
No. 99. Same as No. 98.

RECAPITULATION.

The Vent Pipes on Trap Open.—In experiments No. 1 to No. 9 the top of the soil-pipe being closed, the only means of ingress for air to fill the vacuum is through the traps or their vents. This is the most severe test to which the traps can be subjected for siphonage. The fresh-air inlet being closed, the air in the pipes between the

down-coming water and the running trap must necessarily find its way out through the running trap or through one of the traps connected with the soil-pipe. A strong current of air did in every case pass outward, through the vent pipe. Such strains would never occur in actual work, unless the soil-pipe and fresh-air inlet should happen to become stopped. This is of rare occurrence in the top of the soil-pipe, sometimes happening from collections of snow or frost. The fresh-air inlet, as it is generally put in, may be easily closed by earth or dirt collecting on the perforated or grated opening. Experiments from No. 9 to No. 11: The fresh-air inlet was open; back pressure was not great, while the siphon effect was the same. The condition of experiments from No. 11 to No. 34 were what would exactly have to be encountered in actual practice. The simple lead **S**-trap is acknowledged by all, to be the trap which is the most easily siphoned. It will be seen by referring to the experiments from No. 1 to No. 34, that in no case was I able to siphon or force by back pressure the seal of an **S** or any other kind of trap when it was properly vented. From that I conclude, that

Traps, when Properly Ventilated, Are Not Siphonable.—It has been asserted that when the vent is placed on the crown of a trap that in time it becomes choked up by refuse matter adhering to the surface. In these experiments the vent has been put in different positions, and it makes no difference in its effectiveness as long as it is between the trap and the vertical soil-pipe. With a little care the **Y** can be so placed and shaped that matter passing through the pipe would not adhere to the vent.

Experiments from No. 20 to No. 34 were tried with the vent on roof more or less closed. By these, it can be seen that a vertical vent-pipe less than 3 inches, when the trap is connected with the 4-inch soil-pipe, causes a commotion in the trap, and a pipe of half its area with a discharge from the tank through a 2-inch opening in the tank drew five-eighths of an inch out each time. This discharge was no greater than would come from a bath-tub. The trap was completely siphoned when the outlet was seven-eighths closed, with a discharge equal to three-plunger closets.

When the Vents Were Closed.—From No. 35 to No. 99. All traps failed from either siphonage or back pressure. The experiments from No. 35 to No. 48: The top of the soil pipe was open and the fresh-air inlet closed, in this way submitting the traps to the most severe strain they would have to withstand from back pressure. Every trap failed, except the ball-traps.

Experiments from No. 49 to No. 65, inclusive. The soil-pipe and fresh-air inlet being open were similar to the action traps would receive in every-day use. In every case the traps failed or siphoned, except the Sanitas.

I would call special attention to several experiments, No. 49 to No. 59. The discharge being 15.5 gallons through the 2-inch opening in the tank was hardly as severe on the trap as a discharge from a bath-tub. In every case except that of the Sanitas the traps failed.

In No. 49 a 4-inch trap similar to a hopper-closet trap and a small wash-basin; Bennor's trap, a combination often found in

bath-rooms, and a large S-trap were siphoned by a discharge no greater than would come from a bath-tub in a story above. Such traps will always be used, and should never be put in without vent-pipes.

No. 55 to No. 60. Intended to represent a water-closet, wash-basin, and bath-tub connection, water extracted from traps at each discharge, and the Bowers' trap acting as a vent, the water was taken out to the seal at the third discharge. The wash-basin or bath-trap was then partly closed, as would happen in actual use, by the plug, and the S-traps were siphoned by a discharge no greater than would come from a bath-tub in the fourth story.

Experiments Nos. 66 to 71, inclusive, were more severe than such traps would be subjected to, except in unusual contingencies—*i. e.*, the stoppage of the two air-inlets. All failed. These tests were no more severe than ventilated traps were subjected to.

In the experiments from No. 72 to No. 89, inclusive, the siphon action was greater than actual practice, while the effect of back pressure would be less, the air confined between the running-trap and the soil-pipe having free escape through the fresh-air opening.

No. 85 to No. 89 show how the air in the soil-pipe was forced through the trap. All the traps failed.

Experiments No. 90 to No. 99 were with discharges into a horizontal pipe on the ground floor. The traps were not affected, although the vents were closed.

No. 94 to No. 95. Water discharged from the tank in the fourth story, blew the water out of the trap.

Back pressure seems, from the experiments, to be a more important feature in plumbing than is generally supposed. Although the fresh-air inlet was open, the air confined in the pipes almost invariably found egress more easily through traps on second and first floors than through the opening near the foot of the soil-pipe. No trap withstood back pressure better than the others.

DEDUCTIONS.

(1.) The seals of ventilated traps are safe against siphonage and back pressure.

(2.) The seals of unventilated traps are never safe from siphon action or back pressure, except in deduction four.

(3.) The vertical vent should be three inches, with a four-inch soil-pipe.

(4.) Traps connected on a horizontal pipe and fixtures discharging on the same level into horizontal pipe apparently have no effect on unventilated traps.

(5.) All varieties of non-mechanical traps are more easily affected by back pressure than by siphonage.

(6.) The ball-traps were not affected by back pressure, but by siphonage.

(7.) The Sanitas trap withstood siphon action better than any of the patent traps, but was easily affected by back pressure.

(8. The sewer air is more liable to enter unawares by back pressure through the seal of the trap, because the seal remains unbroken.

(9.) Difference in friction of iron and lead pipes made no apparent difference in the effect on the traps.

The experiments will be continued as to other matters of moment.

Experiments have been made on evaporation of water in traps and the different methods of testing soil-pipes for leakage; but the matter is not yet sufficiently complete to put in this report.

Very respectfully,

GLENN BROWN.

To T. J. TURNER,
Medical Director, U. S. N., In Charge Museum of Hygiene,
Bureau of Medicine and Surgery.

EXPLANATION OF ILLUSTRATIONS.

A—Entrance to sewer.

B—Running trap.

C—Direct outlet to sewer.

D—Fresh air inlet.

E—Gate valves.

F—Double Y's.

G—Four-inch branches.

K—Two and three inch branches.

N—Supply pipe.

O—Four-inch iron opening in tank.

T—Lead vent pipes.

P—Lead vent pipes.

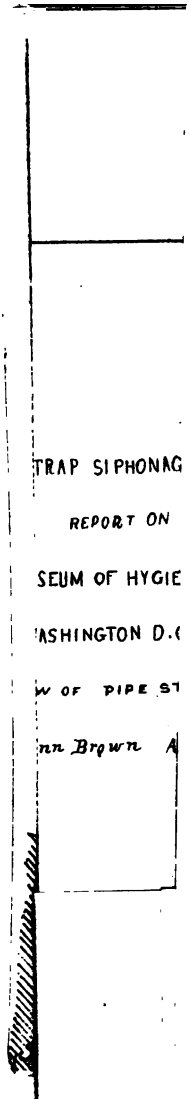
Q—Four-inch lead opening in the tank.

R—Two-inch opening in the tank.

V—Water-closets in the first floor of the Museum.

The drawing shows the plan of second story detached; otherwise it would be hidden by the third story.

The views of traps are enlarged, the dotted line showing the water line.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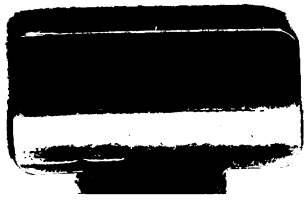
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